METHOD AND APPARATUS FOR DETERMINING THE RECEPTIVITY OF RADIO SIGNALS

Technical Field

The invention relates to a method of determining the receptivity of wireless signals in a broadcast system and to a receiver for performing the operations necessary for the reception.

The invention may be especially practiced in a broadcast system, especially in a common frequency system, with the wireless signals embracing, for example, the transmitting stations, program signals and/or program varieties which can be received. For when receiving radio transmitting stations with mobile receivers, for instance in an automotive vehicle, it is desirable to determine the programs which can be received at any given receiving location. Such programs may include, for instance, traffic reports or information relating to a traffic conduction system.

State of the Art

Present day analog frequency modulated (FM) transmission methods react sensitively to variations in field strength and to multi-path reception the effects of which may only partially be reduced, for instance, by elaborate change-over strategies to so-called alternative

frequencies which are transmitted as components of the radio data signals (RDS). Defining the location of a station by means of a mobile receiver has hitherto required elaborate measures. Thus, complex circuit arrangements are required, often even including two receiving sections, reference transmitters and/or lists of alternative frequencies stored in the receiver. The latter is required for switching, wherever possible without delay and inaudibly, to alternative frequencies in case a program tuned in on a mother station can either not be received at all or poorly only. To obtain, depending upon the actual receiving location, data about receivable programs is possible to a limited extent only with existing systems, such as, for example, the aforementioned RDS. Moreover, the scanning operations for finding receivable transmitters and their identification require a relatively long time.

A method utilizing the radio data signals of at least three stationary transmitters for passive evaluation to define a location with a mobile wireless receiver is known from German patent specification 4,107,116. The publication states that the method offers the possibility of linking the defined position coordinates of the mobile wireless receiver with route-specific and/or geographic identification signals of traffic reports transmitted via the RDS signal over the traffic message channel. In this manner, only those reports which are significant to the instantaneous location are selected from the transmitted reports; all others are faded out. The disadvantage of such a system is that the operator has to preselect the given program variety, such as, in the present example, the traffic report, so that prior to his selection he does not know whether he will receive anything at all, or what it will be. Hence, it will take some time after one or more

searching operations until the operator will actually receive the desired information.

To achieve qualitatively excellent wireless audio transmission corresponding to the quality standard offered by digital storage media (for example DAT), a standard was developed for a terrestrial digital transmission method, known as DAB (digital audio broadcasting). One of the essential characteristics of the DAB method is the common frequency operation of the transmitters employed for a receiving area, with all of the transmitters being connected in a frequency and phase locked relationship and the modulation contents of the individual carriers being identical for all transmitters. From German Patent Specification 4,223,194 it is known that a receiver suitable for DAB may simultaneously be utilized for defining a location, so that no additional receivers are required. Additional transmitters are also not required.

Moreover, German Patent Specification 4,222,877 describes how regionally or locally different data may be transmitted in a DAB network with technical means, without interfering with the common frequency transmission of locally identical data. The transmission of regionally different data is specifically carried out by additional transmission from the transmission station of individual carrier frequencies which are preferably transmitted in a time slot of a transmission window which is also utilized for synchronizing the receiver. The receiver, for performing receiving operations, is provided with a memory and an indicator, additional data being stored in the memory by means of a data record associated with each transmission station. They may either be displayed on the indicator, or they should enable the operator of the receiver to improve the

quality of the reception, for instance, by changing the receiving parameters. The specification only discloses how regionally limited data can be transmitted with technical means within a DAB network.

Description of the Invention

Proceeding from the state of the art described supra, it is the task of the invention to provide a method of, and a receiver for, determining the receptivity of wireless signals in a broadcast system such that any wireless signal desired by an operator may be quickly and reliably tuned in on his receiver or receiving device at any given location within a receiving area.

The task is accomplished by the elements described hereinafter.

The invention provides for a method and for a receiver for carrying out this method, by means of which data about receivable wireless signals may be determined, and presented for selection by an operator, at any location within a receiving area served by one or more transmitters of a broadcasting system.

The wireless signal thereafter selected by the operator is tuned in directly on his receiver and is thus available for further uses at the actual receiving location, for instance for actualizing and/or supplementing data stored in the receiver proper or in a data carrier (for instance a chip card) which either is connected with the receiver or has to be connected with the receiver for data actualization. In one embodiment of the invention as applied to a broadcast system, the further utilization of the selected wireless signal such

as, for example, a program, consists primarily of making the program tuned into the receiver audible to the operator through loudspeakers. Another kind of use resides in the presentation of visual information, such as maps, on a video monitor.

The invention may be used particularly for determining the receptivity of transmitters, program signals and/or of program varieties and, where appropriate, other wireless signals in a broadcast system. Preferably, the transmitters will be operating in a common frequency mode, and they may be stationed on earth or extra-terrestrially, as on satellites, for instance. Aside from audio programs, the program signals may selectively include data programs also. Program variety connotes kinds of programs such as popular music, sports or classical music which depend upon a particular broadcast station or chain of broadcast stations by which they are transmitted. Methods known, for instance, from radio technology or satellite navigation systems are utilized for exact or approximate determinations of the receiving location. A method of defining a location suitable for a DAB broadcast system which uses a phase comparison hyperbola method, has been described in German Patent Specification 4,223,194.

It is of advantage to determine especially the reliably receivable transmitters, program signals and/or program varieties at a given location within a receiving area. They are readily determinable owing to the transmitting power of the individual transmitters and their locations, whereas the overrange reception, for instance, may uncontrollably change because of different weather conditions or because of sun spot activity.

Broadcast stations are located, and their

transmitting power is determined, such that a receiving area is preferably divided into several partial areas so that the same reliably receivable transmitters, program signals and/or program varieties may be received at any location within each of those partial areas. Thus, for each partial area a single list of data relating to the reliably receivable transmitters, program signals and/or program varieties will suffice. These local lists, hereinafter sometimes referred to as "B-lists", are transmitted by the stations, preferably by arranging all local B-lists in succession. The B-list sequence thus created is broadcast by all stations. In a special embodiment of the invention, the B-lists are stored in the receiver, and the stations transmit only data concerning changes to be made in the B-lists stored in the receiver. Such changes may relate to program changes at relatively short notice. Except for transmission errors in the transmitted actualizing data for the B-lists, the storage of the B-lists will be error free, thus resulting in a considerably greater reliability for the operator.

In addition to the B-lists, an A-list will be used which contains the identification signals of all transmitters, program signals and/or program varieties which may in principle be received in the receiving area. This A-list is transmitted by the stations. In a further embodiment of the invention, the A-list is stored in the receiver, preferably in an external mass storage or bulk memory. "In principle be received" means, in particular, that the A-list is set up with free spaces for stations which are existing but which are not transmitting or for stations which are in the planning stage only. If a new transmitter is added to the transmission network, or if an old transmitter is turned off, the list A will be actualized correspondingly. Hence, in the previously

mentioned embodiment of an A-list stored in a receiver only these changes need be transmitted. In the A-list, changes will occur rather infrequently, whereas in the B-lists program changes of short notice will be reflected.

The B-list valid for a given receiving location will be selected from the B-lists, and more particularly from the B-list sequence, on the basis of the defined location coordinates of the receiving location or on the basis of location data relating to the associated partial area. On the basis of the local B-list, the appurtenant identification signals of the transmitter, program signals and/or program varieties are selected from the A-list and are made available for the user's selection by a visual or voice signal. The user is thus apprized of the transmitters, program signals and/or program varieties receivable at his actual receiving location, and may, if he wishes, select a particular transmitter and/or a particular program and/or a particular kind of program. Following selection by the user, the desired item is directly tuned into his receiver.

In a broadcasting system, such as the DAB system, in which several frequency blocks of a predetermined bandwidth are frequency transmitted in a side-by-side manner, and in which a receiver is probably capable of receiving only one such frequency block at any given time, care must be taken that such receiver does not only recognize the program contents of its frequency block but also the program contents of other, adjacent frequency blocks. This is accomplished in the local B-lists by the use of data relating to receivable transmitters, program signals and/or program varieties which may also be received in other frequency ranges, channels or frequency blocks. This ensures that the user is given an indication of the transmitters, program signals and/or

program varieties receivable for his selection at his receiving location. It is of particular advantage that it is not necessary to detune the receiver and that an indication of receivable transmitters, program signals and/or program varieties is given at a shorter time. Conversely, more programs may be offered to the user at the same indication interval.

In a particular embodiment of the invention, it is not only the B-list valid at a given receiving location which is selected at this actual location and is stored in the receiver, but also the B-lists for the adjoining partial areas. Upon changing the receiving location, the same situation is created on the basis of the stored B-lists of the immediately adjoining partial areas. The B-lists of those partial areas which are no longer adjoining the new receiving location are erased from the memory, and the B-lists of the newly added partial areas are added to the memory. Storing of the B-lists of adjoining partial areas is advantageous since by utilizing the directional data of the changing receiving location the data relating to receivable transmitters, program signals and/or program varieties may quickly and reliably be put at the disposal of the user, for his selection, when changing into an adjoining partial area. The user will either generally or upon request be given an indication whether the program he is currently receiving can still be received, or not, after changing to an adjoining partial area. He may then make a new selection or he may arrange, by means of the priority selection of a program variety, at least to receive a program of the kind selected by him.

Where the receiving area is divided into partial areas in a pattern approximating a chessboard, there will be eight adjoining areas for each partial area. Hence,

when the receiving location is moved diagonally in the square of a partial area, five B-lists will always have to be erased as well as added. When changing the receiving location in a direction parallel to the limits of the partial areas, only three B-lists times two need be changed which can, however, be accomplished quickly.

B-lists preferably made up of sequences of (program/variety) numbers, each one represented by a 16-bit-address, are of further advantage, for they can quickly be read into a receiver, and because of their low memory space requirements they permit the use of random access memories (RAM's) for storing local B-lists and/or B-lists of adjoining partial areas.

By the use of local B-lists and their linking to the A-list, the invention provides for utilizing advance information thereby more quickly indicating for a user's choice the transmitters, program signals and/or program varieties which can be received and, furthermore, ensuring him of a high degree of certainty as to the reception of a selected program or program variety. This is evident from the fact that the memory requirements for several B-lists stay within limits so that not only the actual B-list but also the B-lists of the adjoining partial areas may be stored in commercially available memory components.

The invention will hereinafter be described in greater detail on the basis of embodiments, with reference to the drawings, in which:

Fig. 1 is an excerpt of a map;

Fig. 2 are excerpts of a list A and of a sequence of B-lists with correlated numbers;

Fig. 3 is a formatization of a B-list;

Fig. 4 is a receiver.

Fig. 1 depicts an excerpt of a map into which the borders of a broadcast area D have been entered in their entirety, and the borders of adjoining broadcast areas A_I, B_I, C_I, A_{II}, and BII have been partially entered. Individual transmitters have been shown in Fig. 1 by subscript numbers on the right next to the symbol of the broadcast area. For differentiation, local and regional transmitters have been identified by index L. The entire surface of each of the broadcast areas is served by one or more common frequency networks. The areas A_I and B_I as well as B_I and B_{II} are spatially sufficiently divided to allow identical transmission frequencies to be allotted to areas A_I and A_{II} as well as B_I and B_{II}, without any possibility of mutual interference. At low transmitting power, the frequencies defined for local and regional transmitters in one broadcasting area preferably coincide with the frequencies of the adjoining areas; where the transmitting powers are too great, adjoining areas will employ different frequencies.

The data transmitted as A-list in the common frequency network of broadcast area D contain program data PI and program variety PS, similar to an RDS system, of all transmitters which can be received. This list also contains the program identification signals of those programs which are transmitted from adjoining areas at the borders of a broadcast area and which can be received, as well as the identification signals of all receivable local and regional transmitters. Furthermore, data relating to receivable transmitters, program signals and/or program varieties which are receivable in other frequency ranges, channels or frequency blocks are

transmitted in the A-list. All identification signals of the A-list are identified by consecutive natural numbers (Fig. 2). In a common frequency network the program identification signals valid for the environment of individual transmitters are transmitted in individual lists which consist only of number sequences of the numbers of the A-list. Fig. 2 depicts the beginning of the A-list, starting with program varieties PS_1, PS_2, and so on, of station D_1 in broadcast area D. Following this are the program varieties of the local transmitters and the program identification signals of the remaining stations. Starting with program variety PS_1 of station D_1 natural numbers beginning with 1 are allotted in ascending order to the program identification signals. Below the excerpt of the A-list there is shown in Fig. 2 the beginning of the B-list sequence represented by symbols. At the beginning, there is shown the identification signal of a transmitter, in this case D_1, followed by the numbers of those program identification signals of the A list the programs of which can be received at locations in the vicinity of transmitter D_1. This is followed in the sequence of B-lists by an analogous enumeration for transmitter D_2 and so on.

As shown in Fig. 3, a local B-list is made up of a defined number of bytes. After a start command in byte I, there follows in byte II the data for which transmitter X of the common frequency network the following list of numbers of program identification signals is valid. In bytes III through n the numbers of the program identification signals valid for transmitter X are listed in accordance with their correlation to list A. This is followed by the end of the identification signal of a B-list in byte n+1. By sequentially arranging such formatted B-lists there is created a B-list sequence of which Fig. 3 depicts only the end

identification signal n+1 of B-list B_Y of transmitter Y, the entire B-list B_X of transmitter X and the first byte I of B-list B_Z of transmitter Z.

By means of the transmitter location identification signal of the nearest transmitter of the common frequency network which is receivable at the receiving location the receiver initially selects the B-list which applies to the receiving location. On the basis of this B-list the program identification signals valid for the actual receiving location are selected from the A-list and kept in a memory for the emission of an indication.

Only the programs of the common frequency network D can be received at locations near transmitter D_5. The programs of transmission networks D, A_I and B_I can be received at a receiving location near transmitter D_1. The programs of the transmission network D as well as of the local transmitters DL_{11}, DL_{12}, DL_{13} and DL_{14} can be received at receiving locations near transmitter D_8. The programs of transmission networks D, B_I, A_{II}, as well as the programs of local transmitters BL_1 and BL_2 are receivable at a receiving station near transmitter D_{10}. The programs of the transmission networks D and B_{II} can be received near transmitter D_{16}.

The operating mode of a receiver for practicing a first embodiment of the method in accordance with the invention will hereafter be explained on the basis of Fig. 4.

The receiver is provided with a first receiving component (1) for receiving und decoding of the transmitter location identification signal. In stage (2) connected to receiving component (1) the identification signal of the transmitter location of the currently

received transmitter is evaluated. This identification signal is fed to a memory (3) to be stored therein.

A further receiving component (4) of the receiver receives data by way of a B-list and an A-list. In stage (5) which is connected to the receiving component (4), the data contained in the B-lists are specially selected. In the selection stage (6) the B-list valid for the actual receiving location is selected on the basis of the available transmitter location identification signal or location data and is stored in a further stage (7).

Those data received by the receiving component (4) which contain the program identification signals and their numbering (A-list) are selected in stage (8). The program identification signals valid for the receiving location are selected from the read-in A-list on the basis of the data relating to the B-list valid for the actual receiving location and contained in memory (7), and stored in memory (10). From this memory the program identification signals are fed to an indicator where they are available to be called up by a user or listener. The indicator may be a video display or a voice emitter.

The display on a monitor or the voice emission of the programs receivable at the receiving location is initiated by an input from the user in stage (12), as by pushing a key "call up". The receivable programs will then appear on the monitor in succession with a sufficient dwell time (for instance 3 seconds). Should the listener wish to change to one of the indicated programs, he may prompt the change in the receiver to a currently indicated program by pressing a "new selection" key. The program identification signal which appears in the indicator is transferred to a further stage (13). By pressing the key "new selection" the (selected) program

identification signal is transferred to the receiver in a receiving component (14) which tunes in the corresponding program.

At a change in the program and/or a change of the transmitter location identification signal or of the receiving location the entire process described above is released again, and the contents of every memory are replaced.

In a second embodiment of a receiver for practicing the method in accordance with the invention selection of a predetermined program variety leads to an indication of only those programs in the display which fall under the selected variety.

In a further embodiment another generally known and available method for determining the actual location or receiving location, such as, for instance, a method of satellite navigation or other traffic navigation systems, is used instead of the location identification signal of the received transmitter. The coordinates of the actual receiving location determined thereby are stored in memory (3) and are utilized for selecting the B-list applicable to the actual receiving location.